Predictor of academic performance: personality traits and catechol-O-methyltransferase polymorphisms

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Article Info

ABSTRACT

Personality traits and genetics are important factors in determining academic performance. Although there have been studies on the association between genetics and academic performance, there is limited data on the effect of personality traits and the catechol-O-methyltransferase (COMT) rs4680 polymorphism on academic performance, particularly among university students in Malaysia. The objective of this study was to correlate the relationship between personality traits, COMT rs4680 polymorphism, and academic performance among health sciences undergraduate students at a Malaysian university. The research design was a correlational study where 221 students were recruited based on the convenient sampling approach. The demographic and international personality item pool (IPIP) questionnaires were administered online, whereas the COMT rs4680 single nucleotide polymorphism (SNP) was determined using a tetra-primer allele-specific polymerase chain reaction (PCR). From the IPIP results, the conscientiousness trait was positively and significantly correlated with academic performance (r=0.141, p=0.036). Participants with homozygous Met/Met allele of the COMT rs4680 polymorphism tended to perform better in academics (p=0.009) as compared to participants with homozygous Val/Val and heterozygous Val/Met alleles. As a conclusion, students with a higher conscientiousness score and carriers of the homozygous Met/Met allele of COMT rs4680 showed better academic performance.
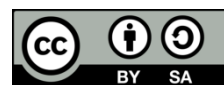
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1. INTRODUCTION

Academic performance refers to an individual's demonstration of knowledge and skills in educational settings. Empirical research has reported a variety of predictors, including openness, self-efficacy, and even random life events, that influence the academic performance of university students [1]–[3]. Historically, research on the identification of academic performance predictors focused heavily on

cognitive abilities like intelligence [4]. However, cognitive abilities alone were insufficient to predict academic performance; a more nuanced and context-sensitive perspective on trait–performance relationships is required [5]. Non-cognitive factors such as personality traits were also responsible for the differences in performance outcomes. In fact, personality traits have been shown to be a more accurate predictor of academic performance, particularly at higher levels of education [6]. Personality refers to the enduring and relatively stable traits, characteristics, and qualities that define a person's essence. The five-factor model, also known as the "Big Five", is a prominent theory in the field of psychology that proposes personality can be understood through five broad dimensions: extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience [7].

The Big Five model has been applied to investigate behaviors and important life outcomes such as learning and academic performance [8]. For example, students with high extraversion preferred to communicate through interaction and discussion, however, students with low extraversion preferred written communication [9]. It has been established that agreeableness is a predictor of academic performance, with highly agreeable students performing better academically [10]. Students who obtained a high score of conscientiousness had better academic performance since they organized their plan and activities thoroughly [11]. The majority of neuroticism's aspects were negatively correlated with motivation, with the exception of trait-level anxiety, which significantly contributes to academic motivation via defensive pessimism, resulting in greater motivation due to fearing the worst [12]. Finally, positive correlations were found between openness to experience and academic performance [1].

It is intriguing to understand how genes affect cognitive processes mediated by the prefrontal cortex (PFC). The catechol-O-methyltransferase gene (COMT) encodes catechol-O-methyltransferase enzyme (COMT), a methylation enzyme involved in the degradation of catecholamines in the prefrontal cortex, including dopamine, epinephrine, and norepinephrine [13]. COMT is abundantly expressed inside the human brain and is responsible for most of the dopamine degradation in PFC. Nevertheless, the COMT rs4680 (Val158Met) polymorphism is also a common single nucleotide polymorphism (SNP) that corresponds to a transition of guanine (G) to adenine (A) nucleotide in exon 4 of the COMT gene and results in the substitution from valine (Val) to methionine (Met) at residue 158 [14]. Polymorphism of COMT enzyme have been associated with cognitive functions [15]. Studies to correlate gene polymorphisms with personality traits have been of interest. For instance, the COMT rs4680 polymorphism decreases COMT enzyme activity, leading to a higher level of extracellular dopamine in PFC [16] which reasoned to individuals with the homozygous met/met allele of the rs4680 SNP in the COMT gene had a better cognitive ability [17]. Essentially, the functional polymorphic marker Val158Met contained in the COMT gene has been reported to affect working memory [18] and executive functions [19].

As part of providing a high-quality education to the nation, the identification of academic performance predictors is helpful for designing teaching and learning activities based on the student's personality traits and genetics. It was previously reported that personality traits such as openness and conscientiousness were positively linked with the academic performance of health sciences students in Malaysia [20]. Previously, we have associated the rs4680 SNP in the COMT gene with cognitive ability [21]. A significant association between COMT rs4680 polymorphism and academic performance has been reported, but the available data on the relationship of personality traits and COMT rs4680 polymorphism on academic performance among university students is still scarce, particularly in Malaysia. Therefore, this study examined the relationship between personality traits and COMT rs4680 polymorphism on academic performance among Malaysian university undergraduates majoring in health sciences.

2. RESEARCH METHOD
2.1. Study design and participants
The university's Research Ethics Committee (Reference Number: REC/365/16) reviewed and approved the study protocol. A correlational study involving 221 undergraduate students from the Faculty of Health Sciences at a Malaysian university was conducted. Due to the participants' accessibility, a convenient sampling method was utilized to recruit them. The demographic and international personality item pool (IPIP) [22] questionnaires were administered online to each participant. Participants were categorized into three distinct groups based on their cumulative grade point average (CGPA). The three groups included students with a CGPA below 3.01, students with a CGPA between 3.02 and 3.56, and students with a CGPA greater than 3.57. A total of 2 ml of whole blood was drawn from each participant into a blood collection tube (BD Vacutainer®, USA). The tubes were kept at -20 °C before being subjected to DNA extraction and genotyping of COMT rs4680 polymorphisms using allele-specific polymerase chain reaction (PCR) techniques.

2.2. Measurements

The IPIP was used to assess the personality traits of each participant. The IPIP is founded on the lexical hypothesis, which proposes that significant individual differences in personality are reflected in the language used to describe people. It includes items that cover a broad range of personality traits and constructs, allowing researchers and practitioners to assess and study personality in a comprehensive manner. Extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience are measured by the IPIP model. These personality measures were frequently used to access personality traits related to academic performance [23]. The IPIP consists of fifty Likert-scale questions ranging from 1 (strongly disagree) to 5 (strongly agree). Internal consistency was measured using Cronbach's alpha to determine the reliability of the scale. Extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience had respective α coefficients of 0.76, 0.63, 0.69, 0.77, and 0.64. The COMT rs4680 polymorphism was genotyped according to our previous study's procedures [21].

2.3. Statistical analysis

Version 20 of the IBM statistical package for social science (SPSS) was utilized for data entry and the generation of descriptive statistics. Using a one-way analysis of variance (ANOVA), personality traits, the COMT rs4680 polymorphism, and academic performance were compared. Pearson's correlation coefficient (r) was utilized to analyze the relationship between personality traits and academic performance. Using a multiple regression analysis, the variables associated with academic achievement were determined. A probability (p) value of less than 0.05 was regarded as statistically significance.

3. RESULTS AND DISCUSSION

Cognitive abilities alone were insufficient to predict academic performance because non-cognitive factors such as personality traits have also been demonstrated able to be a predictor of academic performance [24]. In this study, a total of 221 students have participated, and the demographic characteristics data is presented in Table 1. Descriptive statistics showed that the percentage of CGPA and results of the IPIP questionnaire data satisfied the normality plot.

Table 1. Demographic characteristics (N=221)

	Characteristics	Frequency	Percentage (%)
Gender	Male	24	10.9
	Female	197	89.1
Program	Bachelor of Nursing (Hons)	101	45.7
	Bachelor of Medical Laboratory Technology (Hons)	120	54.3
CGPA	Student with ≤3.01 CGPA	35	15.8
	Student with 3.02-3.53 CGPA	153	69.2
	Student with ≥3.54 CGPA	33	14.9

Table 2 displays the one-way ANOVA for the IPIP score of students in different CGPA groups. It was revealed that personality traits had no effect on the CGPA of the students in different groups. Table 3 displays the results of a correlation analysis using Pearson's correlation coefficient to determine the relationship between personality traits and academic achievement. A positive correlation indicates that the IPIP score for the personality trait is proportional to the CGPA, whereas a negative correlation indicates that the two variables move in opposite directions. A p-value of less than or equal to 0.05 indicates that the correlation is statistically significant. Conscientiousness (r=0.141, p=0.036) and openness to experience (r=0.096, p=0.154) were positively correlated with academic performance, whereas extraversion (r=-0.036, p=0.593) agreeableness (r=-0.075, p=0.270) and neuroticism (r=-0.027, p=0.686) were negatively correlated with academic performance. The finding for this study however demonstrated that only conscientiousness was positively and significantly correlated with CGPA, implying that students with a higher score of conscientiousness obtained a higher CGPA. This result is consistent with previous research on personality traits and academic achievements [25], [26]. Previously, conscientiousness has been reported to be the most reliable and effective predictor of academic performance [27]. In general, individuals with conscientiousness are optimistic, goal oriented and confidence, hence in contrast, individuals with low conscientiousness were flexible and spontaneous but could also be described as sloppy and unreliable [28].

Genotyping analysis showed 60.1% and 63.6% of students with CGPAs of 3.02-3.53 and ≥3.54, respectively, have Val/Val polymorphism Table 4. This study also indicates a significant role of the COMT rs4680 polymorphism in academic performance Table 5. According to the findings, homozygous Met/Met allele carriers of the COMT rs4680 polymorphism exhibited a tendency toward improved academic performance.

Table 2. Mean of IPIP score of students in different CGPA groups determined by one-way ANOVA

Personality traits	CGPA			p-value
	≤3.01 (N=35)	3.02-3.53 (N=153)	≥3.54 (N=33)	
Extraversion	27.37±5.163	28.07±5.571	26.55±7.851	0.378
Agreeableness	35.63±4.243	35.85±4.438	35.12±4.735	0.665
Conscientiousness	32.40±4.053	33.31±5.062	34.73±5.597	0.154
Neuroticism	30.03±4.662	28.83±6.049	29.58±5.333	0.481
Openness to experience	29.09±3.033	30.78±4.257	30.82±4.812	0.075

Table 3. Correlation between personality traits and CGPA

Personality traits	r	p value
IPIP		
Extraversion	-0.036	0.593
Agreeableness	-0.075	0.270
Conscientiousness	0.141	0.036*
Neuroticism	-0.027	0.686
Openness to experience	0.096	0.154

Table 4. Genotype distribution of COMT rs4680 (Val158Met) polymorphism

Genotypes	Met/Met	Val/Met	Val/Val
CGPA ≤3.01	0 (0.0 %)	18 (51.4%)	17 (48.6%)
CGPA 3.02-3.53	9 (5.9%)	52 (34.0%)	92 (60.1%)
CGPA ≥3.54	3 (9.1%)	9 (27.3%)	21 (63.6%)

Table 5. Relationship between COMT Val158Met polymorphism and academic performance (CGPA)

COMT rs4680 polymorphism	N	Mean	SD	F	p value
Met/Met–mutant	12	3.42	0.170		
Val/Met	79	3.21	0.274	5.175	0.009*
Val/Val–wild	130	3.28	0.267		

To predict the factors influencing academic performance, a multiple regression analysis was conducted, taking into account personality traits and the COMT rs4680 polymorphism in relation to CGPA. The variables selected using backward elimination techniques are presented in Table 6. According to the findings of the fourth model, agreeableness, conscientiousness, and openness to experience were statistically significant predictors of CGPA (R=0.198, F=2.95, p=0.033). The best explanatory variables in the final step of the backward multiple regression were agreeableness and conscientiousness as the predictors of academic performance (R=0.186, F=3.890, p=0.022). The conscientiousness score was revealed as the greater relative weight which accounts for 17.8% of the variance in CGPA. Meanwhile the agreeableness score was the second weight variable in the sense negative explaining 12.6% of the variance in CGPA.

Table 6. Multiple regression analysis of personality traits and COMT rs4680 polymorphism on the academic performance (CGPA) with backward elimination selection variables

Model	Standardized coefficient (Beta)						R
	Extraversion	Agreeableness	Conscientiousness	Neuroticism	Openness to experience	COMT rs4680 polymorphism	
1	-0.025	-0.128	0.160*	-0.041	0.077	-0.014	0.205
2	-0.026	-0.127	0.161*	-0.042	0.078	-	0.204
3	-	-0.134	0.162*	-0.045	0.075	-	0.203
4	-	-0.136	0.156*	-	0.074	-	0.198*
5	-	-0.126	0.178*	-	-	-	0.186*

*Correlation is significant at the 0.05 level. (2-tailed)

Results in this study suggest the ability of homozygous Met/Met allele carriers of the COMT rs4680 polymorphism to perform relatively better in academics correlated with conscientiousness. It is well established that cognitive functions, in particular learning and memory, are strongly influenced by the neuromodulator dopamine via sensory input gating, working memory content maintenance, and motor command transmission [29]. Thus, low levels of dopamine could result in lack of motivation and a struggle to memorize or retain memories. The effect of the COMT rs4680 polymorphism has been linked to the level

of dopamine and physiological stress. Met allele carriers were found to be associated with state and trait anxiety, whereas Val homozygotes are typically better at processing emotions due to an increase in dopamine. In response to stressful conditions, Val homozygotes appear to have superior emotional processing and regulation compared to Met allele carriers [30]. Met allele carriers appear to have an advantage in executive function and working memory over Val homozygotes [31]. However, the trait anxiety in Met allele carriers is interesting for future investigation.

Learning anxiety and learning engagement have been linked to class competition and academic achievement. Class competition may negatively impact students' academic achievement by increasing their learning anxiety, but positively impact their academic achievement by increasing their learning engagement [32]. Previous study has shown a correlation between mathematics anxiety and the ability to simultaneously solve mathematical problems [33]. However, mathematics anxiety was also found to be negatively associated with the student engagement towards learning [34].

In health sciences courses such as nursing and medical lab technology, students are trained and guided towards academic excellence, clinical or laboratory competencies, and good interpersonal skills, to prepare them to be skilled frontline healthcare providers, but the hospital setting are more challenging. Thus, although homozygous Met/Met allele carriers performed better academically, Val homozygous could be a better emotionally health care provider. Nevertheless, a good educational environment is an important factor to develop full potential for superior cognitive abilities and prevent procrastination [35]. Affective factors, such as the detrimental effects of emotional vulnerability and academic stress, have been shown to have a substantial influence on academic performance [36], [37]. Therefore, despite bearing the homozygous Met/Met allele for the COMT rs4680 polymorphism, the results also implied that the students received a good educational environment at their faculty.

The effect of personality traits and COMT rs4680 polymorphism on academic performance is important for educational researchers. This study found evidence that the students' academic performance may be affected by a combination of non-cognitive, cognitive, and genetic factors. Hence, personality traits and genotypes of students provide an understanding of the cognitive and non-cognitive abilities of students. The lecturer could monitor the behavior of the students and design effective teaching and learning activities. Thereby, the students would be more interested in learning, and their academic performance could be enhanced.

4. CONCLUSION

The findings showed that personality traits such as conscientiousness and the COMT rs4680 polymorphism correlate with the academic performance of undergraduate students from the Faculty of Health Sciences. Further study exploring the predictors of academic performance from personality traits, genetic factors as well as the modulating effects of different polymorphisms on the academic performance of students, especially in Malaysia, is recommended. This is important as part of providing a high-quality education for the nation.

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